EXHIBIT E

[redacted]

THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

TQ DELTA, LLC, *Plaintiff,* v. **COMMSCOPE HOLDING COMPANY, INC., COMMSCOPE INC., ARRIS INTERNATIONAL LIMITED, ARRIS GLOBAL LTD., ARRIS US HOLDINGS INC., ARRIS SOLUTIONS, INC., ARRIS TECHNOLOGY, INC., and ARRIS ENTERPRISES, LLC,** *Defendants.*	CASE NO. 2:21-CV-310-JRG

EXPERT REPORT OF ARTHUR BRODY, PH.D., ON INFRINGEMENT OF THE FAMILY 1 AND FAMILY 10 PATENTS BY COMMSCOPE

[redacted]

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Table 12-65 – Description of message R-PMD

	Field name	Format
1	Message descriptor	Message code
2	Trellis	1 byte
3	Bits and gains table	$2 \times NSC_{ds}$ bytes
4	Tone ordering table	$3 \times \lceil NSC_{ds}/2 \rceil$ bytes coded as follows: • Bits 0-11: t_{2n-1} • Bits 12-23: t_{2n}
5	Showtime pilot tones	Tone descriptor
6	Initialization status	1 byte
7	ITU-T G.998.4 parameter field	Variable length
8	ITU-T G.993.5 parameter field	Variable length
NOTE – The $\lceil x \rceil$ notation represents rounding to the nearest greater integer.		

Field #1 "Message descriptor" is a unique one-byte code that identifies the message. See Table 12-6 for a complete list of codes.

Field #2 "Trellis" indicates whether trellis coding shall be used in the downstream direction (00_{16} = trellis disabled, 01_{16} = trellis enabled).

Id. at 257 and 258 (emphasis added).

7. SNRM-ROC AND SNRMOFFSET in VDLS2

114. G.993.2 describes an SNR margin for use on the ROC, SNRM-ROC.

11.4.1.1.6.4 Signal-to-noise ratio margin for the ROC (SNRM-ROC)

The SNRM-ROC is the signal-to-noise ratio margin related to transmission of the ROC, as defined in clause 9.1, Figure 9-2. The definition of SNRM-ROC is as in clause 11.4.1.1.6.1 applied to the MPS-TC and BER=10^{-7} for all bits transmitted over latency path #0, Figure 9-2. The SNRM-ROC shall be measured over all subcarriers assigned to the ROC for which $b_i > 0$ in a transmission direction. The received virtual noise PSD as defined in clause 11.4.1.1.6.1.2 shall be taken into account when configured in SNRM_MODE=2.

The SNRM-ROC shall be measured by the receive PMD function during initialization. The measurement may be updated autonomously and shall be updated on request during Showtime. The SNRM-ROC shall be sent to the far-end VTU during initialization and shall be sent on request to the near-end VME at any time. The near-end VME shall send the SNRM-ROC to the far-end VME on request during Showtime. The receive PMD function shall use a special value to indicate that the SNRM value was not measured (e.g., in Loop Diagnostic mode or if the ROC is not enabled or not supported).

The SNRM-ROC shall use the same representation as defined for SNRM in clause 11.4.1.1.6.2.

G.993.2 at 143.

115. G.993.2 further describes the use of an offset to be applied to the SNRM-ROC to increase the target SNR margin. The offset in the downstream direction is added to the target SNR margin in the downstream direction. By adding the offset, SNRMOFFSET-ROC-ds, to the target SNR margin, TARSNRMds, a new, more stringent target margin, TARSNRM-ROC, is applied to the subcarriers in the ROC.

Table 12-49 – Description of message O-MSG 1

	Field name	Format
1	Message descriptor	Message code
2	Downstream target SNR margin (TARSNRMds)	2 bytes
3	Downstream minimum SNR margin (MINSNRMds)	2 bytes
4	Downstream maximum SNR margin (MAXSNRMds)	2 bytes
5	RA-MODE	1 byte
6	NTR	1 byte
7	TPS-TC capabilities	see Table 12-50
8	PMS-TC capabilities	see Table 12-52
9	Downstream Rate adaptation downshift SNR margin (RA-DSNRMds)	2 bytes
10	Downstream Rate adaptation downshift time interval (RA-DTIMEds)	2 bytes
11	Downstream Rate adaptation upshift SNR margin (RA-USNRMds)	2 bytes
12	Downstream Rate adaptation upshift time interval (RA-UTIMEds)	2 bytes
13	Support of "Flexible OH frame type 2" downstream	1 byte
14	SOS Multi-step activation downstream	1 byte
15	SOS Multi-step activation upstream	1 byte
16	MIN-SOS-BR-ds0	2 bytes
17	MIN-SOS-BR-ds1	2 bytes
18	SOS-TIME-ds	1 byte
19	SOS-NTONES-ds	1 byte
20	SOS-CRC-ds	2 bytes
21	MAX-SOS-ds	1 byte
22	SNRMOFFSET-ROC-ds	2 bytes
23	INPMIN-ROC-ds	1 byte
24	G.998.4 parameter field	Variable length
25	G.993.5 parameter field	Variable length
26	REINIT_TIME_THRESHOLDds	1 byte
27	Time synchronization capability	1 byte

G.993.2 at Table 12-49 (highlights added).

> Field #22 contains the value of SNRMOFFSET-ROCds as specified in the MIB. The parameter is defined as the SNR Margin offset for the ROC in the downstream direction. This means that the target margin for the ROC is obtained by adding this value to TARSNRM (i.e., TARSNRM-ROC = TARSNRM + SNRMOFFSET-ROC).
>
> The parameter TARSNRM-ROC is used in the specification of the Channel Initialization Policy (see clause 12.3.7.1).

Id. at 236 (highlights added).

116. The ability to establish a TARSNRM-ROC, to be used on the subcarriers associated with the ROC (*i.e.*, latency path #0), that is higher than the TARSRNM used on the other subcarriers associated with latency path #1 is a mandatory requirement for VDSL2 systems when single latency with ROC mode has been negotiated.

12.3.7.1 Channel initialization policies with ROC

The method used by the receiver to select the values of transceiver parameters described in this clause is implementation dependent. However, within the limit of the total data rate provided by the local PMD, the selected values shall meet all of the constraints communicated by the transmitter prior to the Channel Analysis and Exchange phase, including:

- Message overhead data rate ≥ Minimum message overhead data rate.
- Net data rate ≥ Minimum net data rate for all bearer channels.
- Impulse noise protection ≥ Minimum impulse noise protection for all bearer channels.
- Delay ≤ Maximum delay for all bearer channels.
- SNR Margin ≥ TARSNRM.
- SNR Margin for the ROC ≥ TARSNRM.

Within those constraints, the receiver shall select the values as to optimize in the priority given in one of the priority lists below, where the selection of the list is configured through the CO-MIB Channel Initialization Policy Parameter (CIPOLICY, see clause 7.3.2.10 of [ITU-T G.997.1]). The Channel Initialization Policy applies only for the selection of the values exchanged during initialization, and does not apply during SHOWTIME.

The following Channel Initialization policy is defined:

- Policy ZERO if $CIpolicy_n$=0, then:
  1) Maximize the SNR Margin for the ROC up to TARSNRM-ROC.
  2) Maximize net data rate for all bearer channels, per the allocation of the net data rate, in excess of the sum of the minimum net data rates over all bearer channels (see clause 12.3.5).
  3) Maximize the SNR Margin for the ROC above TARSNRM-ROC.
  4) Minimize excess margin with respect to the maximum SNR margin MAXSNRM through gain adjustments (see clause 10.3.4.2). Other control parameters may be used to achieve this (e.g., MAXMASK, see clause 7.2.3).

Support of Channel Initialization Policy ZERO is mandatory. Additional Channel Initialization Policies are for further study. The $CIpolicy_n$ parameter values other than 0 are reserved for use by the ITU-T.

G.993.2 at 265 (highlights added).

117. Even if SNRMOFFSET-ROC is zero, and TARSNRM equals TARSNRM-ROC, the mandatory Channel Initialization Policy ZERO supports maximizing the SNR margin for the ROC above TARSNRM-ROC.

118. G.997.1 shows that the use of an SNRM offset is supported for both the upstream and downstream directions. These offsets are to be used as described in G.993.2 Section 12.3.7.1 that is shown above.

7.3.1.10.9 Downstream SNR margin offset of ROC (SNRMOFFSET-ROC-ds)

The parameter is defined as the SNR Margin offset for the ROC channel in the downstream direction. The parameter is used in the specification of the channel initialization policy (see clause 12.3.7.1 of [ITU-T G.993.2]).

The valid range of SNR margin offset values is from 0 to 31 dB, with 0.1 dB steps.

7.3.1.10.10 Upstream SNR margin offset of ROC (SNRMOFFSET-ROC-us)

The parameter is defined as the SNR margin offset for the ROC channel in the upstream direction. The parameter is used in the specification of the channel initialization policy (see [ITU-T G.993.2], clause 12.3.7.1).

The valid range of SNR margin offset values is from 0 to 31 dB, with 0.1 dB steps.

G.997.1 at 62 (highlights added).

Table 7-15 – Support of line configuration parameters per Recommendation

Category/ Element	ITU-T G.992.1	ITU-T G.992.2	ITU-T G.992.3	ITU-T G.992.4	ITU-T G.992.5	ITU-T G.993.2	ITU-T G.998.4	ITU-T G.993.5
SNRMOFFSET-ROC-ds						Y		
SNRMOFFSET-ROC-us						Y		

Id. at 104 and 105 (highlights added).

119. The VTU-O does not transmit the upstream SNRMOFFSET-ROC-us to the VTU-R as it is the VTU-O that adjusts the bits and gains it requests the VTU-R to use using the O-PMD message.

C. CommScope BGW210 G.inp-VDSL2 Operation with ROC *Not* Enabled

1. ’354 Patent, Claim 10

409. Based on its G.inp-VDSL2 capabilities, it is my opinion that the BGW210 with the ROC not enabled or not supported by either VTU infringes claim 10 of the ’354 Patent. I base my opinion on the BGW210’s claimed compliance to the G.inp and VDSL2 standards, review of the product specifications and hardware details, review of the testing of the BGW210 when G.inp is appropriately configured and review of the source code analysis demonstrating how it practices the claim.

a. Analysis Differences with Respect to G.inp-VDSL2 Operation with ROC Enabled

410. The BGW210 are compliant with the G.inp standards. *Supra* §XIII.A. The BGW210 is also compliant with the VDSL2 standards. *Supra* §XIII.A. I have reviewed the annexes of G.inp and have found no modifications to the VDSL2 standard that would change my infringement analysis for the CommScope BGW210 with respect to claim 10 of the ’354 Patent.

411. With the ROC not enabled or not supported by either VTU, G.inp will implement single latency with ROC mode and the overhead channel as specified in G.inp. However, as noted below, SNRMOFFSET-ROC will be zero, thus affecting the claim elements with involving SNR margin, namely 10[b], 10[c], 10[e], and 10[f]. Still, even if SNRMOFFSET-ROC is zero, and TARSNRM equals

TARSNRM-ROC, the mandatory Channel Initialization Policy ZERO supports maximizing the SNR margin for the ROC above TARSNRM-ROC. *Supra* §XI.C.7. As the testing for this mode shows, SNR margin for the ROC bits before any shared subcarrier use an SNR margin greater than the SNR margin for the data bits.

C.1.2 Overhead channel

If the ROC is enabled in O-TPS, single latency with ROC mode (see clause 9.1 of [ITU-T G.993.2]) shall be used and the overhead channel shall use the ROC as specified in [ITU-T G.993.2].

If ROC is disabled in O-TPS or is not supported by either the VTU-O or the VTU-R, single latency with ROC mode (see clause 9.1 of [ITU-T G.993.2]) shall be used and the overhead channel shall use the framing parameters as they are derived for the ROC (see framer constraint limitations in Table 12-47 of [ITU-T G.993.2]) with the following configuration:

– SNRMOFFSET-ROC = 0 dB,

– INPMIN-ROC = max(INPMIN_REIN, 2),

with the exception that sub-carriers loaded with the bits of the overhead channel may share sub-carriers loaded with the bits of the latency path #1.

G.998.4 at 56 (highlights added).

412. Another possible difference is "that sub-carriers loaded with the bits of the overhead channel may share subcarriers loaded with the bits of the latency path #1." This could affect claim elements 10[a], 10[b] and 10[d]. However, the bits in each data frame are loaded in the order given by the tone ordering table. *Supra* §XI.C.6. As a result, the first plurality of carriers carrying mostly ROC bits will never be the same as the second plurality of carriers carrying mostly data bits even if any subcarrier is shared by ROC bits and data bits.

413. I also incorporate by reference the Infringement Contentions below:

- U.S. Patent 9,154,354 Claim 10 – Claim Chart for U.S. Patent No. 9,154,354 – F10 – G.inp-VDSL2 – CommScope.

414. Based on the above and the supporting code and test analyses of the BGW210 implementing G.inp with the [redacted], the BGW210 still infringes claim 10 of the '354 Patent because:

- The bits of the ROC and the data bits are two different pluralities,
- The bits of the ROC and the data bits use different pluralities of carriers,
- The SNR margin for the ROC bits is different than the SNR margin for the data bits, and
- The SNR margin for the ROC bits is greater than the SNR margin for the data bits.

b. BGW210 Source Code Analysis for Claim 10

415. I have reviewed the Cooklev Report that provides an analysis of the Broadcom source code set for the BGW210 for claim 10 of the '354 Patent. *See* Cooklev Report Section VII.C.6.b)(2) As discussed above, the BGW210 uses the [redacted]

416. "If the Robust Overhead Channel (ROC) is enabled, and/or if GINP Retransmission Request Channel (RRC) Messages are enabled, different subcarriers are allocated for these separately from the user data on latency path 1, and typically

F. CommScope 5268AC G.inp-VDSL2 Operation with ROC *Not* Enabled

1. '354 Patent, Claim 10

638. Based on its G.inp-VDSL2 capabilities, it is my opinion that the 5268AC with the ROC not enabled or not supported by either VTU infringes claim 10 of the '354 Patent. I base my opinion on the 5268AC's claimed compliance to the G.inp and VDSL2 standards, review of the product specifications and hardware details, review of the testing of the 5268AC when G.inp is appropriately configured and review of the source code analysis demonstrating how it practices the claim.

a. Analysis Differences with Respect to G.inp-VDSL2 Operation with ROC Enabled

639. The 5268AC is compliant with the G.inp standards. *Supra* §XIII.B. The 5268AC is also compliant with the VDSL2 standards. *Supra* §XIII.B. I have reviewed the annexes of G.inp and have found no modifications to the VDSL2 standard that would change my infringement analysis for the CommScope 5268AC with respect to claim 10 of the '354 Patent.

640. With the ROC not enabled or not supported by either VTU, G.inp will implement single latency with ROC mode and the overhead channel as specified in G.inp. However, as noted below, SNRMOFFSET-ROC will be zero, thus affecting the claim elements with involving SNR margin, namely 10[b]. 10[c], 10[e], and 10[f]. Still, even if SNRMOFFSET-ROC is zero, and TARSNRM equals

TARSNRM-ROC, the mandatory Channel Initialization Policy ZERO supports maximizing the SNR margin for the ROC above TARSNRM-ROC. *Supra* §XI.C.7. As the testing for this mode shows, SNR margin for the ROC bits before the shared subcarrier use an SNR margin greater than the SNR margin for the data bits.

C.1.2 Overhead channel

If the ROC is enabled in O-TPS, single latency with ROC mode (see clause 9.1 of [ITU-T G.993.2]) shall be used and the overhead channel shall use the ROC as specified in [ITU-T G.993.2].

If ROC is disabled in O-TPS or is not supported by either the VTU-O or the VTU-R, single latency with ROC mode (see clause 9.1 of [ITU-T G.993.2]) shall be used and the overhead channel shall use the framing parameters as they are derived for the ROC (see framer constraint limitations in Table 12-47 of [ITU-T G.993.2]) with the following configuration:

– SNRMOFFSET-ROC = 0 dB,

– INPMIN-ROC = max(INPMIN_REIN, 2),

with the exception that sub-carriers loaded with the bits of the overhead channel may share sub-carriers loaded with the bits of the latency path #1.

G.998.4 at 56 (highlights added).

641. Another possible difference is "that sub-carriers loaded with the bits of the overhead channel may share subcarriers loaded with the bits of the latency path #1." This could affect claim elements 10[a], 10[b] and 10[d]. However, the bits in each data frame are loaded in the order given by the tone ordering table. *Supra* §XI.C.6. As a result, the first plurality of carriers carrying mostly ROC bits will never be the same as the second plurality of carriers carrying mostly data bits even if any subcarrier is shared by ROC bits and data bits.

642. I also incorporate by reference the Infringement Contentions below:

- U.S. Patent 9,154,354 Claim 10 – Claim Chart for U.S. Patent No. 9,154,354 – F10 – G.inp-VDSL2 – CommScope.

643. Based on the above and the supporting code and test analyses of the 5268AC implementing G.inp with the ROC not enabled or ROC not supported by either VTU, the 5268AC still infringes claim 10 of the '354 Patent because:

- The bits of the ROC and the data bits are two different pluralities,
- The bits of the ROC and the data bits use different pluralities of carriers,
- The SNR margin for the ROC bits is different than the SNR margin for the data bits, and
- The SNR margin for the ROC bits is greater than the SNR margin for the data bits.

b. 5268AC Source Code Analysis for Claim 10

644. I have reviewed the Cooklev Report that provides an analysis of the Broadcom source code set for the 5268AC for claim 10 of the '354 Patent. *See* Cooklev Report Section VII.C.6.b)(1) As discussed above, the 5268AC uses the [redacted]

645. "If the Robust Overhead Channel (ROC) is enabled, and/or if GINP Retransmission Request Channel (RRC) Messages are enabled, different subcarriers are allocated for these separately from the user data on latency path 1, and typically

with higher SNR margin." As a result, the analysis holds true when the ROC is or is not enabled. The [redacted]

646. With respect to G.inp, [redacted]

XVII. CONCLUSIONS

647. Based on the analyses above, it is my opinion that CommScope's BGW210 and 5268AC Accused Products infringe claim 36 of the '686 Patent and claim 10 of the '354 Patent.

Executed on this 29th day of August 2022, in Stamford, Connecticut.

By [signature]
DR. ARTHUR BRODY